



UNIVERSITI PUTRA MALAYSIA

**CHARACTERIZATION AND AMELIORATION OF SELECTED
ACID SULFATE SOILS IN MALAYSIA**

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**CHARACTERIZATION AND AMELIORATION OF SELECTED
ACID SULFATE SOILS IN MALAYSIA**

By

MUHRIZAL SARWANI

**Thesis Submitted in the Fulfilment of the Requirement for
the Doctor of Philosophy in the Faculty of Agriculture
Universiti Putra Malaysia**

July 2001



DEDICATION

To

My late parents,

Mahnita

And to

Our three wonderful sons: Siraj, Fajri and Zaki

Abstract of thesis presented to the Senate of Universiti Putra Malaysia in
fulfilment of the requirement for the degree of Doctor of Philosophy

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Chairman : Prof. Dr. J. Shamshuddin

Faculty : Agriculture

Researchers in the past had focused their study on the common or standard acid sulfate soils, which are characterized by high iron and the presence of jarosite mottles. Little is known about the characteristics and management of iron-poor acid sulfate soils and this study was conducted to provide the dearth of information. This study aimed to characterize and ameliorate acid sulfate soils in Malaysia. Three common acid sulfate soils in Malaysia namely Teluk, Jawa and Linau series were investigated in three phases. The first phase was concentrated on the characterization of the soils. The second phase dealt with laboratory incubation experiments to study oxidation processes. The third phase was on the ameliorative effects of organic materials, lime, phosphate and silicate application on acid sulfate soils.

Results of the study revealed the presence of both iron-rich and iron-poor acid sulfate soils in Malaysia. The former, represented by the Teluk and Jawa soils, had thick accumulation of iron in the B-horizon. They followed the standard morphological profile commonly found under tropical monsoon climate. The latter, represented by the Linau soil, was low in iron content in the B-horizon. The low

content of iron was most probably due to high organic content enhanced by wet climate in Malaysia. The formation of Fe (III) oxide was hindered when the environment was rich in organics.

Incubation study indicated that oxidation of pyrite resulted in a decrease in pH and the formation of jarosite which, in turn, transformed into short-range order Fe-oxides. The yellow mottles formed during pyrite oxidation were jarosite/natrojarosite and alunite as detected by X-ray diffraction analysis. The oxidation of pyrite was retarded by addition of phosphate and silicate. The retardation of pyrite oxidation was probably due to coating of insoluble materials on the pyrite surface.

Reduction conditions could not be established in the Linau soils upon re-flooding; hence no increase in pH and no decrease in Al occurred. The low active iron (Fe-oxalate) was not necessarily be the source of slow reduction process, but low amount of easily mineralizable organic-C plus low pH were responsible for the slow reduction in this soil. Addition of green manure, rice straw and *Eleocharis dulcis* had the most impact on the reduction process in the Linau soil. Under aerobic conditions, the response of Linau soil to the addition of organic materials was positive. Total and monomeric Al concentration as well as monomeric Al activities in the soil solution decreased, while basic cations activities in the soil solution were increased by the addition of organic materials, especially the mixtures of peat and green manure or rice straw. The mixtures had synergistic effects on the complexation and chelating of Al monomeric. The relationship between relative root length of mung bean and various Al indices was generally exponential. Among the indices, Al monomeric activity and Al^{3+} activity were good predictors of Al toxicity. Growth of cocoa seedlings were significantly increased by the addition of peat mixed with

organic materials. Poor growth of cocoa seedlings in the presence of Al^{3+} was manifested by an exponential decrease in the relative total dry weight with increasing activities of Al^{3+} . This study showed that the mixture of peat and green manure provided good conditions for cocoa seedlings growth.

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia
sebagai memenuhi syarat ijazah Doktor Falsafah

**PENCIRIAN DAN PERBAIKAN TANAH ASID SULFAT
DI MALAYSIA**

Oleh

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Para penyelidik di masa lampau menumpukan kajian mereka pada tanah asid sulfat biasa, iaitu tanah asid sulfat yang tinggi ferum serta mengandungi jarosit. Sangat sedikit diketahui mengenai ciri dan pengurusan tanah asid sulfat yang rendah ferum. Kajian ini dibuat untuk mengisi kekosongan maklumat tentang tanah asid sulfat seperti ini. Tiga siri tanah asid sulfat, iaitu siri Teluk, Jawa dan Linau, yang terdapat di Malaysia telah dikaji untuk menentukan sifat dan ciri tanah tersebut dan cara memperbaikinya. Kajian dibuat dalam tiga peringkat. Pada peringkat pertama, kajian dibuat mengenai penciriannya. Pada peringkat kedua, kajian pemeraman dibuat untuk mempelajari proses pengoksidaan pirit. Peringkat ketiga ialah untuk memperbaiki tanah asid sulfat melalui penggunaan bahan organik, kapur, fosfat dan silikat. Kacang hijau dan anak benih koko telah digunakan sebagai tanaman ujian.

Keputusan menunjukkan bahawa kedua-dua tanah asid sulfat tinggi dan rendah ferum dijumpai di Malaysia. Jenis tanah yang pertama, diwakili oleh tanah siri Teluk dan Jawa, mempunyai ferum yang tinggi dalam profilnya, mengikuti profil piawai yang terdapat di kawasan monsun tropika. Sementara itu, jenis yang kedua

diwakili oleh siri Linau, terkurang ferum pada profilnya. Penyebabnya kemungkinan besar ialah pengaruh bahan organik, dibantu pula oleh iklim basah. Dalam suasana seperti ini, pembentukan ferum oksida tergendala.

Kajian pengeraman menunjukkan pengoksidaan pirit telah menurunkan pH dan pembentukan jarosit, yang akhirnya bertukar menjadi ferum oksida. Motel kuning yang terbentuk semasa bahan sulfidik dieramkan adalah jarosit/natrojarosit dan alunite yang dapat dikesan melalui belauan sinar X. Pembentukan motel kuning dan pengoksidaan pirit dapat dicegah melalui rawatan bahan fosfat and silikat. Ini berlaku kerana adanya lapisan selaput tak larut air di permukaan pirit yang dapat mencegah pengoksidaan.

Pembanjiran tanah siri Linau tidak menyebabkan berlakunya keadaan terturun bagi menaikkan pH dan menurunkan kandungan Al. Penyebabnya bukan ferum aktif (Fe-oksalat) yang rendah di dalam tanah siri ini tetapi kerana rendahnya kandungan C organik mudah dimineralisasi serta nilai pH tanah yang rendah. Oleh itu, penambahan bahan organik seperti baja hijau, jerami padi dan *Eleocharis dulcis* dapat meningkatkan proses penurunan tanah siri Linau. Penambahan bahan organik pada tanah siri Linau dalam keadaan aerobik juga memberikan keputusan yang baik. Penambahan bahan organik dapat menurunkan kepekatan Al total dan monomerik serta aktiviti Al monomerik sehingga ianya tidak menjadi toksik lagi. Penambahan bahan organik juga dapat meningkatkan aktiviti bes di dalam larutan tanah. Tanah gambut yang dicampur dengan bahan organik yang berkualiti tinggi seperti baja hijau dan jerami padi ketika digunakan pada tanah asid sulfat memberikan kesan sinergistik. Hubungan diantara panjang akar kacang hijau relatif dan berbagai indeks Al bersifat eksponensial. Aktiviti Al monomerik dan aktiviti Al^{3+} adalah indeks keracunan Al yang baik. Pertumbuhan anak benih koko meningkat secara nyata

dengan rawatan campuran gambut dan bahan organik lain. Terbantunya pertumbuhan anak benih koko dengan kehadiran Al^{3+} ditunjukkan oleh penurunan secara eksponensial berat kering total dengan bertambahnya Al. Kajian ini menunjukkan bahawa campuran gambut dan baja hijau memberi keadaan yang baik bagi pertumbuhan anak benih koko.

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I certify that an Examination Committee met on 18th July 2001 to conduct the final examination of Muhrizal Sarwani in his Doctor of Philosophy thesis entitled "Characterization and Amelioration of Selected Acid Sulfate Soils in Malaysia" in accordance with Universiti Pertanian Malaysia (Higher Degree) Act 1980 and Universiti Pertanian Malaysia (Higher Degree) Act 1981. The committee recommends that the candidate be awarded the relevant degree. Members of the Examination Committee are as follows:

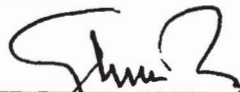
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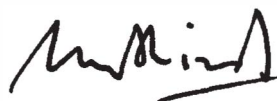
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I hereby declare that this thesis is based on my original work except for quotations and citations which, have been duly acknowledged. I also declare that it has not been previously or concurrently submitted for any other degree at UPM or other institutions.



MUHRIZAL SARWANI

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TABLE OF CONTENTS

	Page
DEDICATION	ii
ABSTRACT	iii
ABSTRAK	vi
ACKNOWLEDGEMENTS	ix
APPROVAL SHEET	xi
DECLARATION FORM	xiii
TABLE OF CONTENTS	xiv
LIST OF TABLES	xviii
LIST OF FIGURES	xx
LIST OF PLATES	xxv
LIST OF ABBREVIATIONS	xxvii

CHAPTER

I	INTRODUCTION General Introduction Objectives of the Study	1 1 6
II	REVIEW OF LITERATURE Historical Background on the Research of Acid Sulfate Soils Distribution and Occurrences of Acid Sulfate Soils Distribution Occurrence Properties of Acid Sulfate Soils Classification Field Identification Morphology Physico-chemical Characteristics Mineralogical Properties Effects of the Acid Sulfate Soil Properties on Living Organisms Chemical Processes in Soil and Soil Solution Accumulation and Formation of Pyrite Oxidation Processes Reduction Processes Managing the Soils By the Farmer's Way By Water Management By Liming	7 7 8 8 9 9 10 11 14 15 16 17 19 19 20 23 24 25 26 28



	By Addition of Organic Materials	28
	Environmental Problems Related with Acid Sulfate Soils	29
	Need for the Study	31
III	CHARACTERISTICS OF SELECTED ACID SULFATE SOILS IN MALAYSIA	34
	Introduction	34
	Material and Methods	35
	Study Sites	35
	Soils	37
	Physical Analysis	38
	Chemical Analysis	39
	Mineralogical Analysis	42
	Data analysis	43
	Results and Discussion	44
	Morphology	44
	Physico-chemical characteristics	46
	Mineralogical properties	65
IV	METAL CONTENTS AND THEIR FRACTIONS IN SELECTED ACID SULFATE SOILS OF MALAYSIA	77
	Introduction	77
	Materials and Methods	78
	Soils	78
	Chemical Analysis	79
	Examination by SEM-EDX	79
	Data Analysis	81
	Results and Discussion	81
	Pyrite Crystal and its Impurities	81
	Total Concentration of Metals	82
	Fraction of Fe and Trace Elements as Assessed by Sequential Extraction	86
V	TRANSFORMATION OF IRON AND ALUMINIUM, RELEASE OF METALS AND FORMATION OF HYDROXY-SULFATES DURING ACID SULFATE SOILS WEATHERING	96
	Introduction	96
	Materials and Methods	98
	Materials	98
	Oxidative Experiment	98
	Chemical Analysis	99
	Characteristic of Yellow Mottles Formed during Oxidation	100
	Examination by SEM-EDX	101

	Results and Discussion	101
	Formation of Hydroxy-sulfates during Oxidation of Pyrite	101
	Changes in pH and EC	104
	Fe and Al Transformation	106
	Solution Chemistry and Formation of Hydroxy-sulfates	108
	Changes in Pyrite Morphology	112
	Release of Metals during Oxidation of Pyrite	113
VI	INHIBITING EFFECTS OF VARIOUS MATERIALS ON PYRITE OXIDATION IN ACID SULFATE SOIL	116
	Introduction	116
	Materials and Methods	117
	Materials	117
	Incubation Experiment	118
	Chemical Analysis	119
	SEM-EDX Analysis	120
	Data analysis	120
	Results and Discussion	121
	Results	121
	Discussion	132
VII	pH, Eh AND CHEMICAL CHANGES DURING SUBMERGENCE OF AN ACID SULFATE SOILS AS AFFECTED BY ADDITION OF ORGANIC MATERIALS	137
	Introduction	137
	Materials and Methods	138
	Materials	138
	Experiment 1	140
	Experiment 2	141
	pH and Eh Measurement	142
	Soil Solution Analyses	142
	Solid Phase Analysis after Submergence	143
	Data Analysis	143
	Results and Discussion	143
	Organic Materials Composition	143
	Experiment 1	145
	Experiment 2	149
VIII	EFFECT OF LIME, PEAT AND OTHER ORGANIC MATERIALS ON SOIL SOLUTION AND SOLID PHASE CHANGES, ROOT ELONGATION OF MUNG BEAN AND GROWTH PERFORMANCE OF COCOA SEEDLINGS GROWN ON AN ACID SULFATE SOIL	165
	Introduction	165

	Materials and Methods	167
	Materials	167
	Experiment 1	167
	Experiment 2	169
	Root Elongation Test	170
	Experiment 3	170
	Soil Solution Analysis	172
	Solid Phase Analysis	174
	Data analysis	174
	Results and Discussion	175
	Experiment 1	175
	Experiment 2	188
	Experiment 3	205
IX	SUMMARY AND CONCLUSIONS	216
	Summary	216
	Conclusions	229
	REFERENCES	232
	APPENDICES	250
	BIODATA	256

LIST OF TABLES

TABLE		Page
3.1.	Macromorphological characteristics of the Teluk, Jawa, and Linau soils	45
3.2.	Selected physical characteristics of the Teluk , Jawa and Linau soils	47
3.3.	Al and Mn fraction in the Teluk, Jawa and Linau soils	53
3.4.	Calculated soil solution composition of the Teluk, Jawa and Linau soils	55
3.5.	Chemical characteristics of the Teluk, Jawa and Linau soils	58
3.6.	Relationship between EC and other soil attributes	59
4.1.	Total heavy metal concentration in the Teluk, Jawa and Linau soils	87
4.2.	Correlation (r) matrix between total metal concentration and some soil parameters of three acid sulfate soils	88
4.3.	Chemical treatments and corresponding geochemical phases for metals extracted from acid sulfate soils (after Griffin et al., 1989)	89
4.4.	Correlation (r) matrix among metals extracted with H ₂ O ₂	95
4.5.	Correlation (r) matrix among metals extracted with dithionite citrate bicarbonate (DCB)	95
5.1.	Na/K ratio in yellow precipitates from two acid sulfate soils	102
5.2.	Calculated soil solution activities of incubated pyritic samples in the Jawa and Linau soils	111
5.3.	Saturation quotient (Ω) of soil solution activities with respect to mineral common acid sulfate soils for the Jawa and Linau soils	112
5.4.	Total and water-soluble metal concentration in the pyritic samples of the Jawa and Linau soils	113
6.1.	The amount of Fe-oxide relative to the initial value of Fe-oxide in the pyritic samples (unoxidized) and the Fe-jarosite	128

7.1.	Chemical composition of organic materials used in the study	144
7.2.	Correlation (r) matrix between pe and some quality indices of organic materials used	152
7.3.	Correlation (r) matrix between pH and some quality indices of organic materials used	152
7.4.	Relation (r) between Ca, Mg and K in soil solution and the contents of and quality index of organic materials used	160
7.5.	Correlation (r) between Ca, Mg and K in soil solution and in solid phase	161
8.1.	Chemical composition of organic materials used in this study	168
8.2.	Correlation (r) matrix between concentration of ions in soil solution and their respective ions in solid phase as fractions or as their absolute value	185
8.3.	Concentration of Al, Ca, Mg and K in soil solution	196
8.4.	Correlation coefficient (r) between ions in the soil and organic materials	196
8.5.	Calculated Al and major basic actions activities as affected by addition of organic materials	197
8.6.	Critical value of various Al indices	204
8.7.	Effect of the mixture of peat with other organic materials on exchangeable Al and major basic cations	206
8.8.	Effect of the mixture of peat with other organic materials on soil solution Al and major basic cations	206
8.9.	Aluminum and nutrients in the leaves of cocoa seedlings as affected by addition of mixture peat with other organic materials	212
8.10.	Correlation coefficient (r) between elements in the leaves and their corresponding contents in soil and soil solution	212

LIST OF FIGURES

Figure	Page
3.1 Approximate location of studied areas (indicated by star)	36
3.2 Iron fraction in the Teluk (a), Jawa (b) and Linau soils	49
3.3 Saturation quotient (Ω) [$\text{pK}_{\text{S}_0} - \log(\text{IAP})$] of the three acid sulfate soils studied	52
3.4 Relationship between pH and Exchangeable Al (a) and Al saturation (b)	59
3.5 Percentage occupation by Al and basic cations in the Teluk (a), Jawa (b) and Linau soils(c)	63
3.6 Relationship between TAA and pH (a)/Al saturation (b); TPA with Fe (c), sum acidic ions (d), SO_4 (e) and S-total (f)	66
3.7a XRD pattern of clay fraction in Bw_{3j} (upper) and Cg (lower) of the Teluk soil	68
3.7b XRD pattern of clay fraction in Bw_{3j} (upper) and Cg (lower) of the Jawa soil	69
3.7c XRD pattern of clay fraction in Bw_{3j} (upper) and Cg (lower) of the Linau soil	70
4.1 Relative Fe-fraction in the Teluk (a), Jawa (b) and Linau soils (c)	90
4.2 Relative Zn-fraction in the Teluk (a), Jawa (b) and Linau soils (c)	92
4.3 Relative Ni-fraction in the Teluk (a), Jawa (b) and Linau soils (c)	93
4.4 Relative Co-fraction in Teluk (a), Jawa (b) and Linau soils (c)	94
5.1. XRD pattern of yellow mottles from the Jawa and Linau soils incubated for 12 weeks	103
5.2 Changes in pH during incubation of pyritic samples from the Jawa (a) and Linau soils (b)	105
5.3 Changes in EC during incubation of pyritic samples from the Jawa (a) and Linau soils (b)	105
5.4 The Fe-fraction in the two acid sulfate soils at the initial	107

5.5	The formation of Fe-jarosite during incubation of pyritic samples from the Jawa (a) and Linau soils (b)	108
5.6	The formation of Fe-oxalate during incubation of pyritic samples from the Jawa (a) and Linau soils (b)	108
5.7	Percentage of the formation of Fe fraction during incubation of pyritic samples from the Jawa (a) and Linau soils (b)	109
5.8	The formation of Al-oxalate during incubation of pyritic samples from the Jawa (a) and Linau soils (b)	109
6.1	EDX pattern of pyritic materials from the Jawa soil treated with phosphate (using pyrite crystal in Plate 6.2d)	126
6.2	EDX pattern of pyritic materials from the Jawa soil treated with silicate (using framboid of pyrite in Plate 6.2f)	126
6.3	pH changes during pyrite oxidation in the Jawa soil as affected by addition of various materials	127
6.4	EC changes during pyrite oxidation in the Jawa soil as affected by addition of various materials	127
6.5	Effect of phosphate, silicate, lime and peat application on water-soluble Fe, jarosite Fe and other forms of Fe after oxidation of sulfidic materials from the Jawa soil	130
6.6	Effect of phosphate, silicate, lime and peat application on water-soluble Fe, Al and Mn after oxidation of sulfidic materials from the Jawa soil	130
6.7	Exchangeable cations and Al of pyritic materials from the Jawa soil after incubated for 12 weeks as affected by addition of various materials	131
6.8	Relative occupation by cations and Al in the exchange site of pyritic materials from the Jawa soil after incubated for 12 weeks as affected by addition of various materials	131
7.1	Changes in pH of the soil solution upon flooding as affected by addition of various materials. Bars represent Lsd at 0.01 probability level	146
7.2	Changes in pe of the soil solution upon flooding as affected by addition of various materials. Bars represent Lsd at 0.01 probability level	146

7.3	Changes in pH of the soil solution upon flooding as affected by addition of organic materials. Bars represent Lsd at 0.01 probability level	150
7.4	Changes in pe of the soil solution upon flooding as affected by addition of organic materials. Bars represent Lsd at 0.01 probability level	150
7.5	Kinetics of iron in the soil solution upon flooding as affected by addition of organic materials	156
7.6	Stability relations of Fe minerals in the Linau soil with pe-pH measurement during flooding as affected by addition of organic materials	156
7.7	Relative percentage of cations in the exchange complex after flooding as affected by addition of organic materials	157
7.8	Changes in Ca of the soil solution upon flooding as affected by addition of organic materials	161
7.9	Changes in Mg of the soil solution upon flooding as affected by addition of organic materials	162
7.10	Changes in K of the soil solution upon flooding as affected by addition of organic materials	162
7.11	Changes in Al of the soil solution upon flooding as affected by addition of organic materials	164
7.12.	Aluminium saturation in the exchange complex after flooding as affected by addition of organic materials	164
8.1	Effect of peat and lime on soil pH. Bar represents Lsd 0.05	179
8.2	Effect of peat and lime on exchangeable Al. Bar represents Lsd 0.05	179
8.3	Effect of lime on cations composition in the exchange complex	179
8.4	Effect of peat on cations composition in the exchange site	179
8.5	Relation between pH and exchangeable Al	179
8.6	Effect of peat and lime on exchangeable Ca. Bar represents Lsd 0.05	179
8.7	Relation between pH and exchangeable Ca	181
8.8	Relation between exchangeable Ca and exchangeable Al	181
8.9	Effect of peat and lime on exchangeable Mg	181

8.10	Effect of peat and lime on exchangeable K	181
8.11	Effect of peat and lime on solution pH	181
8.12	Effect of peat and lime on Al in solution	181
8.13	Effect of peat and lime on Al-monomeric concentration (a); and relationship between soluble Al and pH, note that the dashed line (peat) were shifted to the left of the broken line (lime)(b)	184
8.14	effect of peat and lime on solution Ca concentration (a); and relationship between pH and solution Ca. Note that the dashed line (peat) were shifted up of the broken lime (lime only) (b)	184
8.15	Effect of peat and lime on solution Mg concentration (a); and on solution K concentration (b)	184
8.16	Relationship between pH and Mg in solution (a); and pH with Ca in solution (b)	185
8.17	Relative root length of mung bean as affected by addition of peat and lime	187
8.18	Relationship between relative root length (RRL) and monomeric Al (a), total Al in solution (b), Ca in solution (c), and solution pH (d)	187
8.19	Soil solution pH (a) and soil pH (b) as affected by addition organic materials	192
8.20	Exchangeable Al (a), monomeric Al concentration (b) and total Al in the soil solution (c) as affected by addition of organic materials	192
8.21	Relationship between pH and exchangeable Al (a), total Al in solution (b) and monomeric Al concentration (c). Note that in (a) linear relationship was obtained without organic materials addition while exponential relationship was obtained for all data	193
8.22	Relationship between calculated Al monomeric activity and measured Al monomeric concentration (a), relationship between pH and Al monomeric activity (b), and with Al^{3+} activity and pH (c).	198
8.23	Exchangeable Ca (a), exchangeable Mg (b) and exchangeable K (c) as affected by addition of organic materials	199
8.24	Relationship between exchangeable Ca and Ca^{2+} activity (a), exchangeable Mg and Mg activity (b) and exchangeable K and K activity	202
8.25	Relative cation activities as affected by addition of organic materials	202

8.26	Relationship between relative root length of mung bean and various indices of aluminium toxicity	203
8.27	Relationship between Al^{3+} activity and Al measured with aluminon (a); and Al monomeric activities and Al measured with aluminon (b)	208
8.28	Relationship between ions activities and ions in solid phase	208
8.29	Effect of mixture of peat and other organic materials on top dry weight (a), plant height (b) and root dry weight (c)	210
8.30	Relationship between Al in the leaves of cocoa seedlings and relative top dry weight (a); and relative plant height (b)	213
8.31	Relationship between relative top dry weight (RTDW) and various Al indices	214